Title
Growing Progress in the Evolving Science, Business, and Policy of Sustainable Nutrition.

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Title: Growing progress in the evolving science, business, and policy of sustainable nutrition

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Abstract: A session at the annual meetings of the American Society of Nutrition was convened in June 2018 to identify the nutrition science that is needed in order to help make evidence-based evaluations on what foods and eating patterns are both sustainable and nutritious; and to discuss the role of various stakeholders on the actions needed to implement food systems that deliver "sustainable nutrition." This term has emerged where distinct streams of scientific discourse now overlap: in global change, environmental science, agriculture, food security, nutrition, sustainable development, and public health. The sustainability challenges linked to the global agri-food system are enormous, and nutrition science is embracing a research agenda to help humans meet their collective nutrition needs in more sustainable ways, given the existential threat posed by climate change and other environmental stressors. Fortunately, momentum is building in pursuit of sustainable nutrition among consumers, businesses, scientists, and policymakers. However, the science is still evolving and political processes are complex and sometimes polarized. Actions highlighted within the session included the need to: (1) carefully define terminology and agree upon quantifiable measures, metrics, and methods of assessing the status of sustainable nutrition, including scientific measures of environmental sustainability based on life-cycle assessment (LCA); (2) evaluate appropriate approaches, roles, & responsibilities of stakeholders across the entire food system (scientists, policymakers, public health professionals, private companies, and allied healthcare providers) to achieve more sustainable and nutritious outcomes; and (3) pursue the critical role played by plant-based foods as part of healthy eating patterns that can help meet nutritional needs in more sustainable ways.

Keywords: environmental sustainability; food systems; sustainable diets; life cycle assessment (LCA); specialty crops; plant-based foods; sustainable nutrition

Introduction

In recent years, the companion themes of "sustainable nutrition" and "sustainable diets" have emerged where distinct streams of scientific literature have widened and begun to overlap, in the areas of global change, environmental science, agriculture, food security, sustainable development, nutrition, and public health (1). The intersection of nutrition and environmental sustainability has spawned a vigorous scientific, public, and political debate (in the United States and elsewhere) on the role that environmental considerations should play in shaping diet, including whether government-issued dietary guidance should explicitly include consideration of the relative environmental consequences of different foods (2–5). Based on health and nutrition considerations alone, such guidance has consistently recommended a diet with higher amounts of nutrient-dense plant-based foods (e.g. fruits, vegetables, legumes, nuts, whole grains) and smaller amounts of animal-based foods. A consensus is emerging in the scientific community that such diets are also associated with lesser environmental impact (6).

The idea of linking sustainability considerations to dietary patterns has been in the scientific literature for at least 30 years (7), but the specific topic of "sustainable diets" first took prominence on the global stage at a major international conference co-organized by FAO and Bioversity in Rome in 2010 (8). In plenary, the gathered experts endorsed the following definition:

> *Sustainable Diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.*

A common theme in much of the recent literature is the sharpening realization of the challenge that food systems face to deliver sustainable nutrition, due to multiple colliding constraints, including human population pressure, resource scarcity, ecosystem degradation, and climate change (9). The Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) highlighted the effects of water scarcity and higher temperatures on crop yields, and the higher food prices and diminished food security that are likely to result (10). Unfortunately, the causality of these effects operates in both directions. The food system, writ large, is a significant source of GHG emissions, both directly and indirectly (via land use change).(11).

It was against this back-drop that a special session was convened during the June 2018 meetings of the American Society of Nutrition (ASN): "Growing a Healthy Sustainable Plate: Understanding Scientific, Political, and Business Perspectives on Sustainable Nutrition." This paper is a structured synthesis of the primary themes that emerged from the session, and it concludes with a set of implications and recommendations for the broader research community.

Environmental Impacts of the Global Agri-Food System

Agriculture is in many realms the footprint of humanity. It uses approximately 11% of land globally (or 1.5 billion ha) (12), is the largest user of freshwater, and consumes significant quantities of other resources, including several (such as phosphorous) that are finite and non-renewable. Agriculture is practiced on individual farms, and those farms are in communities, scattered across the world. It alters ecosystems and even climate at the landscape, regional and global scales. However, the environmental footprint of the global agri-food system is much more than just about what happens on farms. Myriad other activities in food supply chains also have major environmental impacts: transport, storage, processing, retailing, preparation, consumption, and lastly and perhaps most tragically – the methane emissions generated by food uneaten and discarded.

The question of whether these environmental impacts would be dramatically reduced if diets shifted in a healthier direction, is driving a rapid increase in published research in this area. For example, a pair of formal systematic reviews (3,5) on this topic were conducted only 18 months apart, using identical search strategies and terms, and demonstrated that the total amount of research on this had increased by about 50% over that relatively brief period of time. As this growing body of scientific work is published, a persistent suggestion is emerging: is it possible that as diets become more healthful or more nutritious, the corresponding environmental burdens of those diets decrease? The most recent systematic review found that a dietary pattern higher in plant-based foods as well as lower in total energy, has improved health outcomes (e.g. reduced cardiovascular risk, less obesity, etc.) as well as a lesser impact on the environment (e.g. reduced GHG emissions, less land and irrigation water use, etc.) (5). This key finding is consistent with a somewhat earlier modeling study (6), which found that alternative diets (more plant-based) could reduce global agricultural greenhouse gas emissions, reduce land clearing and resultant species extinctions, and help prevent diet-related chronic non-communicable diseases. While this possible convergence of future dietary benefits is encouraging, neither the current health status of the planet nor our current public health is. Accordingly, the need for such research to move out of the science journals and into the dietary patterns and other behaviors of all consumers is undeniably urgent.

Measuring Sustainable Nutrition through Life Cycle Assessment (LCA)

The environmental component of sustainable nutrition is generally characterized through some form of Life Cycle Assessment (LCA), which attempts to quantify the full suite of environmental impacts associated with a particular food or diet, beginning with the production of inputs and then including all of the intervening steps leading up to consumption and management of waste (13). In LCA modeling, defining the system boundary and scope are important first steps in comparative environmental impact assessments. LCA methodologies are governed by ISO international standards (14), which enables them to rigorously and reliably characterize and compare various components of food systems, ranging from entire diets to individual food items.

Results are not always intuitive. For instance, the energy required to produce dried milk is high, but the cooling requirements and heavier transport weight for fluid milk lead to even higher energy requirements, with the net effect that the dried version ultimately uses less energy per unit of consumed milk (15). As noted in a pivotal paper by Heller et al., the full application of LCA to food systems requires the development of regionally specific life cycle inventory databases for food and agriculture, and the expansion of the scope of assessments beyond only GHGs (16–19). Other elements of LCA still lack consensus. For instance, the use of different functional units (e.g. calories, protein content, etc.) for reporting the relative environmental sustainability (e.g. carbon and water footprints, etc.) of different foods dramatically alters their apparent relative impacts (20). In addition to this important consideration when interpreting of LCA results, it should be noted that methods to broaden LCA to include the relative economic and societal benefits of various foods are still in their infancy.

Two specific examples of LCA results were shared during the ASN session: almonds and mushrooms. The almonds analysis considered typical almond orchard production systems for California, where more than 80% of commercial almonds on the world market are produced. The comprehensive, multiyear LCA includes orchard establishment and removal; field operations and inputs; emissions from orchard soils; and transport and utilization of co-products. These processes were analyzed to yield a life cycle inventory of energy use, greenhouse gas (GHG) emissions, criteria air pollutants, and direct water use from field to factory gate (21). Results show that 1 kilogram (kg) of raw almonds and associated co-products of hulls, shells, and woody biomass require 35 megajoules (MJ) of energy and result in 1.6 kg carbon dioxide equivalent (CO_2e) of GHG emissions. Nitrogen fertilizer and irrigation water are the dominant causes of both energy use and GHG emissions. Model sensitivity for net energy consumption is highest for irrigation system parameters, followed by biomass fate and utilization (22). Opportunities to improve the environmental footprint of almonds include finding the best uses for co-products, like hulls used as feed for dairy cattle and the generation of renewable electricity using the actual woody biomass coming out of the orchard. It's important to note that publication of LCA results such as these is helping to motivate and accelerate environmental improvements throughout the industry. Almond growers are continually working to improve by finding the best uses for co-products, including efforts to improve soil health using recycled woody biomass from the orchard, and repurposing almond hulls and shells for animal and insect feed.

Mushrooms are a unique food crop, grown in the absence of sunlight and in climate controlled environments. In a first LCA for US-based mushroom production, primary data for operations were collected from compost and mushroom producers in the USA, representing approximately one third of US mushroom production (23). The results from this study demonstrate that 1 kg of mushrooms generate 2.13 to 2.95 kg CO_2e GHG emissions, slightly lower than previous mushroom LCAs conducted for Australian and Spanish production systems. Electricity and fossil fuels were the most impactful inputs. Recommendations to improve the commercial mushroom production process include reducing electricity and fossil fuel use through on-site renewable energy generation. This recommendation is primarily relevant to mushroom producers in the Eastern region of the USA, where the electricity grid is the most coal and fossil fuel-intensive.

These two examples of food LCAs highlight some of the challenges of quantifying environmental sustainability of food choices and the challenge contextualizing or comparing foods. The first is that production systems are immensely variable – the perennial almond production system with important co-products and the energy-intensive irrigation water, or the indoor, climate-controlled growing conditions of mushroom production (which are dependent on highly variable regional electricity grids) demonstrate just how different systems can be, and illustrate the problem of generalizing across foods and their life cycles. Similarly, while both mushrooms and almonds are nutrient-rich plant foods, comparing them to one another on a mass or calorie basis, or defining a role in the human diet is challenging. To make these kinds of assessments useful for informed food choices, future work should contextualize the results of food LCAs in the context of nutrition, meal, or diet-level assessments to enable informed food choices.

Research Needs

Many activities and interventions are underway at local and regional levels in an attempt to enhance sustainable nutrition, but they are generally not well-coordinated or resourced. Moreover, rigorous and quantitative analyses of the environmental sustainability of foods is not common, and not necessarily consistent. Broad questions related to choosing a functional unit (the basis for comparison) in LCAs of foods, requirements for the scope of analysis and consensus on data collection or data sources, could all improve the consistency and comparability of food LCAs. In addition, companies could play an important role in producing rigorous and objective LCAs at the product level. For example, while not yet standard practice in the U.S., some food companies in Europe have developed Environmental Product Declarations (EPDs) (24). EPDs are third-party verified LCA-based assessments, somewhat analogous to a nutrition label, but for environmental information, and may be an opportunity for food companies to take active measures to quantify and compete on the basis of product sustainability. This is one potential pathway for companies to take active roles in providing the environmental information required for decision-making on sustainable nutrition choices

Consumers, Policy & Voluntary Initiatives

Recent public polling information indicates that an increasing percentage (now 60%) of US consumers believe that sustainability is very important when it comes to purchasing food (25). A subsequent survey (26) indicates that the most important element of sustainability continues to be pesticide use, but the factor that has now jumped to second place is "ensuring an affordable food supply." Overall, sustainability is still a secondary concern for most consumers, falling well behind taste and price. However, more than half now say that recognizing all ingredients on the label and understanding how the food item has been produced are important factors in a food purchasing decision. More than a third of all consumers (38%) are willing to pay more for food and beverage products that they believe are produced sustainably, compared with 28% who are sure they would not pay more – leaving a third who are unsure. Consumers willing to pay more for sustainable foods tend to be better educated and in better health (26).

To collectively achieve sustainable nutrition at the national scale, all people must have access to a variety of nutritious foods; knowledge, resources, and skills for healthy living; prevention, treatment, and care for diseases affecting nutrition status; and safety-net systems for vulnerable sub-populations (27). The solutions are inherently trans-sectoral, engaging practitioners and experts across agriculture, rural development and public health (28). Policy should support action along entire food supply chains (29), including the food consumption process as a whole: i.e. growing, purchasing, cooking, and eating (30). Ethical issues arise as well. Key ethical issues include how to make societal decisions and define values about food security that impact nutrition outcomes, and the ethical trade-offs between environmental sustainability and ensuring that individual dietary and nutritional needs are met (31). As policy is developed and implemented, it is essential for the entire spectrum of stakeholders to be intentionally engaged, in order to establish common understanding and improve the odds of success (32). Private-sector initiatives can arguably have a faster and greater impact. One example is "Menus of Change: The Business of Healthy, Sustainable, Delicious Food Choices," a ground-breaking leadership initiative launched in 2012 by the Culinary Institute of America (CIA) and Harvard T.H. Chan School of Public Health. It integrates optimal nutrition and public health, environmental stewardship and restoration, and social responsibility concerns within the foodservice industry and the culinary profession (33).

The session alluded to signs the public is beginning to adopt such practices, but the pace of change is generally quite slow due to the immense size and complexity of the food system. However, some recent positive examples showing that relatively more rapid change is possible have taken place with school lunches, trans fats, and "My Plate," from the most recent US Dietary Guidelines (4). It was highlighted that the private sector has a clear role to play in accelerating the pace of change such as the helpful actions recently taken by Danone (34), General Mills (35), Mars (36), and Walmart (37). Companies like these can choose to re-formulate, re-label and market in ways that promotes more healthy behaviors. In the end, because so much food is purchased from companies, positive change will only come when companies themselves change their practices. Government policy has a role, but is fleeting to the extent that can be changed quickly after elections. Accordingly, the food system is shaped much more by the companies who are producing it in reaction to the consumers who are purchasing it – rather than government policy. The consumer-business relationship offers both barriers and opportunities. As of today, the consumer cares far more about health than about sustainability, a fact both public- and private-sector decision-makers must bear in mind.

Conclusions

Consumers have an essential role to play in the evolving science, business, and policy of sustainable nutrition. Current trends suggest that consumers are becoming increasingly aware of the sustainability implications of what they eat, and there is a growing momentum to the ongoing changes in the food system. However, the sustainability challenges associated with the global agri-food system are still daunting, and there is increasing pressure on all of society to meet its nutrition needs in more sustainable ways. The is also significant work to be done to address economic sustainability (especially the tension between farm income and lower consumer prices), as well as the many social aspects of sustainability (e.g. animal welfare, treatment of farm workers, etc.). The ASN session summarized here included ample evidence that consumers, businesses, scientists, and policy-makers are all rising to meet these challenges, particularly as they form novel, cross-sectoral partnerships that have already achieved much success. And the fact that this session was so well-attended is also encouraging evidence that nutrition scientists themselves are becoming part of this growing global conversation about the need to transform food systems.

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